

PHILADELPHIA & READING RAILROAD, DELAWARE RIVER BRIDGE
(Yardley Bridge)
Pennsylvania Historic Railroad Bridges Recording Project
Spanning Delaware River, west of Rotary Island
Yardley
Bucks County
Pennsylvania

HAER No. PA-513

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HISTORIC AMERICAN ENGINEERING RECORD
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Location: Spanning Delaware River, west of Rotary Island, between Yardley, Bucks County, Pennsylvania, and Trenton vicinity, Mercer County, New Jersey.

USGS Quadrangle: Trenton West, New Jersey-Pennsylvania (7.5-minute series).

UTM Coordinates: 18/514960/4454375

Dates of Construction: 1911-13.

Basis for Dating: Construction drawings.

Designer: Philadelphia & Reading Railroad: William Hunter, Chief Engineer, and Edwin Chamberlin, Assistant Engineer.

Builder: F. W. Talbot Construction Co. (New York).

Present Owner: CSX Transportation.

Present Use: Railroad bridge.

Structure Type: Concrete arch.

Significance: The Yardley Bridge, an early, large-scale reinforced concrete structure, is a significant example of its type because of several unusual details. Its closed-spandrel arches are rife with expansion joints and steel reinforcement, perhaps indicating conservative experimentation with a new structural material. The original railing and decorative features remain intact.

Historian: Justin M. Spivey, April 2001.

Project Information: The Historic American Engineering Record (HAER) conducted the Pennsylvania Historic Railroad Bridges Recording Project during 1999 and 2000, under the direction of Eric N. DeLony, Chief. The project was supported by the Consolidated Rail Corporation (Conrail) and a grant from the Pennsylvania Historical and

Museum Commission (PHMC). Justin M. Spivey, HAER engineer, researched and wrote the final reports. Preston M. Thayer, historian, Fredericksburg, Virginia, conducted preliminary research under contract. Jet Lowe, HAER photographer, and Joseph E. B. Elliott, contract photographer, Sellersville, Pennsylvania, produced large-format photographs.

Description and History

There were a number of reasons for constructing a second railroad crossing of the Delaware River near Trenton, but the 1876 U.S. Centennial Exposition in Philadelphia was its singular motivation. Edward Miller, chief engineer of the North Pennsylvania Railroad (North Penn) had surveyed an extension of its Doylestown branch into New Jersey as early as 1853, but even an 1872 re-survey failed to result in construction. Instead, the railroad abandoned this plan and crossed the Delaware at Yardley.¹ The "Yardleyville Bridge" opened to traffic just two months before the Exposition, carrying a new Philadelphia-New York route in direct competition with the Pennsylvania Railroad (PRR). Three railroads — the North Penn, the Delaware & Bound Brook, and the Central of New Jersey — together broke PRR's monopoly on carrying New Yorkers to the Exposition. PRR fought the new route, of course, but a recently passed New Jersey railroad incorporation law allowed the competitors to proceed.² In 1874, the North Penn began constructing a branch from its main line at Jenkintown (north of Philadelphia) to the Delaware River, where it met the Delaware & Bound Brook coming from Bound Brook, New Jersey. From Bound Brook, trains followed the Central of New Jersey's existing tracks to the Hudson River ferries at Jersey City.

The present double-track reinforced concrete bridge at Yardley is but the second structure on this site, replacing a double-track wrought-iron truss bridge that served for almost four decades. In terms of construction expense, the North Penn and the Bound Brook met halfway — each paying for work from its respective shore to the state line at mid-river. McGrann & Fitzpatrick of Lancaster constructed the stone piers, some of which still stand on the upstream (north) side of the concrete bridge. J. H. Cofrode & Co. fabricated and erected the trusses, which were designed by the Bound Brook's Chief Engineer, F. H. Saylor.³ (Cofrode and Saylor subsequently became partners in a bridge construction firm.) In a series of articles about the Exposition, *Frank Leslie's Illustrated Newspaper* published an engraving and extended description of the structure, calling it "a triumph of engineering skill." The 4,000'-0"-long structure consisted of pin-connected double-intersection Pratt truss spans over the Delaware & Raritan Canal and PRR's Belvidere Division tracks on the New Jersey side, separated by a 622'-0" timber trestle from similar truss spans totaling 1,448'-0" over the Delaware River.⁴

The Yardley Bridge and the route it carried were soon acquired by PRR's strongest competitor in eastern Pennsylvania, the Philadelphia & Reading Railroad (P&R). P&R began leasing the North Penn and the Bound Brook on 14 March 1879, forming a more integrated route to New York.⁵ To upgrade its new acquisitions for heavier traffic, P&R strengthened the Yardley

Bridge in 1883, likely replacing the timber trestle with an earthen embankment at the same time. This isolated the spans over the canal and PRR tracks, which were subsequently considered a structure separate from the Delaware River bridge.⁶ Plate-girder spans at either end of the river spans, which do not appear in the *Frank Leslie's* engraving, were evidently installed as part of this effort. A 1909 study for a replacement bridge showed thirteen reinforced concrete closed-spandrel arches in the river, but proposed re-using the plate-girder spans at either end.⁷ This thrifty idea was abandoned in the final design, however.

The final scheme, prepared in 1910, had fourteen closed-spandrel arches and, at 1,445'-6", was almost as long as the truss bridge it replaced. Eleven of the spans are 90'-9" long; three spans on the New Jersey end are slightly shorter at 85'-11" to avoid placing a pier in the Trenton Water Power Canal. The arches have five-centered curvature, are 3'-6" thick at the crown, and rise 35'-0" from springing to crown. The concrete structure follows the grade of the truss bridge, about 74'-0" above low water with a 0.22-percent incline from west to east. It is parallel to, and 35'-0" east of, the old alignment. Measured from coping to coping, the deck is 33'-0" wide. Safety niches, some of which presently contain posts for overhead catenary power, occur over each pier. Between piers, the railing consists of two lines of 4"-diameter steel pipe with plain square concrete posts, most of which remains intact. All of the piers are 10'-0" wide, except for the middle one, which is 20'-0".⁸ The wider pier provides a visual center, which otherwise would be difficult to find because of the bridge's even number of spans.

The wide middle pier served a more practical purpose during construction. Although P&R now controlled the entire Yardley Bridge, the state line still served as a division in construction of the 1911-13 concrete structure, just as it had for the jointly owned truss. One reason for this was the extreme length of the bridge, which would have been difficult to construct in a single effort. P&R bridge engineers designed the middle pier to resist the unbalanced thrust of one-half the bridge. New York-based contractor F. W. Talbot Construction Co. could therefore set up concrete mixing plants on either shore and proceed at different rates on each half. Interestingly, sand and gravel for each half came from different locations.⁹ A consequent variation in concrete chemistry is a likely explanation for the noticeably greater efflorescence and spalling on the Pennsylvania half of the bridge.

National engineering publications paid significant attention to the Yardley Bridge replacement not only because of its large scale, but also because reinforced concrete was a relatively new material in railroad bridge construction. Concrete was valued for its "permanence" and low maintenance cost, as compared to the metals it frequently replaced.¹⁰ Concrete could be considered a local material in eastern Pennsylvania during the early twentieth century, with a significant portion of U.S. cement production in the Delaware River valley. The Delaware, Lackawanna & Western Railroad, a major cement carrier, was among the earliest railroads to experiment with concrete bridges in 1903. The P&R was not far behind, starting construction on two Philadelphia-area bridges the following year. These had closed-spandrel arches with expansion joints at either skewback to control cracking.¹¹ It is unclear what led P&R bridge engineers to the profusion of expansion joints (six per span) found on the Yardley Bridge.

The detail is unusual for a closed-spandrel structure because of the difficulty of waterproofing a moving joint under fill.

Other aspects of the Yardley Bridge's design and construction were similarly conservative and experimental. The continuing climate of uncertainty in reinforced concrete design is revealed by a statement in an *Engineering Record* article, "It is hoped that some reliable information may be secured from [measurements] on the nature of settlement in concrete arches."¹² The arches were scored with radial lines, which perform an aesthetic function in echoing stone voussoirs, but also conceal construction joints. To avoid excessive settlement in the falsework, the arch rings were poured in segments, with final "key" segments pre-compressed to reduce tensile and shrinkage cracks. The Yardley Bridge contains significant amounts of steel reinforcement, twisted square bars, to further control cracking. Longitudinal rods are 3/4" bars, 7" on center, following the curves of intrados and extrados, crossed by transverse 1/2" bars, 36" on center. It is doubtful that the structural design took into account additional tensile strength provided by the steel; articles mention only an allowable compressive stress in the concrete.¹³

P&R employees had an even closer look at the Yardley Bridge's construction, with periodic reports by site engineer Henry L. Laning published in the company magazine. Readers of *The Pilot* followed as work began on the concrete mixing plants (15 May 1911) and excavating the piers (11 July). The contractor positioned timber cribs in the river, which served as guides for driving steel sheet-pile cofferdams down to rock (about 10'-0" below water level). The abutments had been designed with concrete pile foundations, but when driving the piles proved difficult, the contractor used sheet-pile cofferdams and excavated to rock instead. The first concrete pour occurred on 21 July 1911. A narrow-gauge railway on a trestle delivered concrete to piers on the Pennsylvania side; a series of derricks handled concrete from the New Jersey plant.¹⁴ As the piers reached a level 4'-0" below the springing line, they were capped with a 1/2"-thick steel plate on the upstream nosing to serve as an ice-breaker. The trestle was removed following completion of an overhead cableway for concrete delivery on 9 October.¹⁵

No concrete could be poured during the winter, but work continued on the bridge. In December, some piers had risen high enough to construct "umbrella" forms for pouring cantilevered lower portions of the arches in warmer weather. The river's heavy spring flow had subsided by May 1912, allowing construction of arch centers on falsework in the river.¹⁶ Most of the arch rings were complete by September, after which the contractor began pouring haunches and spandrel walls. Following completion of each span, a subcontractor, Hydrex Felt and Engineering Co. of New York, installed waterproofing.¹⁷ After two years of construction, the new Yardley Bridge stood complete in mid-1913. The exact date of its first use could not be determined in researching this report, however.

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Notes

1. Jay V. Hare, *History of the North Pennsylvania Railroad* (Philadelphia: Reading Co., 1944), 3, 17-18, typescript in Paley Library, Temple Univ., Philadelphia, Pa.
2. Jay V. Hare, *History of the Reading* (Philadelphia: ABC Duplicator Co., 1966), 215-16.
3. "The Yardley Bridge across the Delaware River, Philadelphia & Reading Ry.," *Engineering News* 69, No. 22 (29 May 1913): 1101.
4. "The New Philadelphia Route: The Yardleyville Bridge," *Frank Leslie's Illustrated Newspaper* 42, No. 1090 (19 Aug. 1876): 396.
5. Hare, *History of the Reading*, 102.
6. [Henry L. Laning], "New Bridge over the Delaware River at Yardley, Pa.," *The Pilot and Philadelphia & Reading Railway Men* 12, No. 5 (May 1911): 184.
7. Delaware & Bound Brook Railroad, "Bridge over Delaware River, Yardley, Delaware & Bound Brook R. R., Study for Proposed Renewal with Concrete Arches" (16 Mar. 1909), milepost 31.36, region/division/branch 150326, aperture card files, Consolidated Rail Corp., Philadelphia, Pa. [transferred to Norfolk Southern Railway Co., Atlanta, Ga.; hereinafter cited as Conrail aperture cards].
8. Philadelphia & Reading Railway Co., "Proposed Bridge over Delaware River, Yardley Pa., New York Div. P. & R. Ry.," 4 sheets (9 Dec. 1910), Conrail aperture cards.
9. Edwin Chamberlin, "New Delaware River Bridge at Yardley, Pa.," *Railway Engineering and Maintenance of Way* 28, No. 3 (Mar. 1913): 99-100, 105-06.
10. "Changes in Engineering Practice," editorial in *Engineering Record* 66, No. 15 (12 Oct. 1912): 395.
11. Thomas T. Taber III, *The Delaware, Lackawanna & Western Railroad, The Route of Phoebe Snow, in the Twentieth Century, 1899-1960* (Muncy, Pa.: Thomas T. Taber III, 1980), 36; "Double-Track and Four-Track Concrete Bridges on the Philadelphia & Reading Railroad Lines," *Engineering Record* 54, No. 15 (13 Oct. 1906): 396-400.
12. "Yardley Bridge across the Delaware River," *Engineering Record* 66, No. 15 (12 Dec. 1912): 407.
13. *Engineering News*, "The Yardley Bridge," 1102-03.
14. Henry L. Laning, "New Delaware River Bridge at Yardley, Pa.," *The Pilot and Philadelphia & Reading Railway Men* 12, No. 10 (Oct. 1911): 367-68.
15. *Ibid.*, *The Pilot and Philadelphia & Reading Railway Men* 12, No. 11 (Nov. 1911): 397-98.
16. *Ibid.*, *The Pilot and Philadelphia & Reading Railway Men* 13, No. 1 (Jan. 1912): 10-11; and 13, No. 6 (June 1912): 199-201.
17. *Ibid.*, *The Pilot and Philadelphia & Reading Railway Men* 13, No. 9 (Sep. 1912): 299-300; and 14, No. 2 (Feb. 1913): 57-59.

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Additional Sources

1. Edwin Chamberlin, "New Delaware River Bridge of the P. & R.," *Railway Age Gazette* 54, No. 17 (25 Apr. 1913): 944-50, has almost the same text published in *Railway Engineering and Maintenance of Way*, but different illustrations.
2. Philadelphia & Reading Railway Co., "Plan Showing Concrete Bridge #31/36 over Delaware River at Yardley Pa." (31 May 1913), Conrail aperture cards.
3. "Replacing the Yardley Bridge," *Engineering Record* 67, No. 18 (3 May 1913): 493-94, does not pertain to the Delaware River bridge, but a bridge over the Pennsylvania Canal immediately to the west.